2-Wheeled Segway Robot Design: Preliminary Report

Team SR03

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Problem Statement

Design Objectives

Performance Goals

Design Principles

- *Choose off-the-shelf parts* rather than self-made parts whenever possible.
- *Reuse and expand on open-source software libraries* to avoid spending time writing code that duplicates functionality that already exists elsewhere (and is likely more robust).
- *Keep the hardware simple* by using the least amount of hardware necessary for operation to avoid additional potential points of failure.
- *Modularize systems and components*. Each component should do one thing and do it well.

Preliminary Design

Battery System

For our standing robot, we would like to use battery packs to power the onboard computation, sensors, and the two torque motors that will enable the robot to self-balance. The final choice of exact battery pack will rely heavily on the motor test results that are gathered once we acquire and test the motor control in lab. As a preliminary estimation, it is expected that we will need a 9.6V or 12V NiMH (nickel metal-hydride) with a current rating somewhere between 2000 mAh and 10000 mAh. This prediction is based on the fact that similar size batteries are widely recommended for "small" robotics projects.

Wireless (Bluetooth®) Communication

As a design requirement our robot must be controlled through a wireless interface. We have selected Bluetooth® as our wireless protocol. We did this so we would easily be able to connect different devices as controllers. We will have a backup IR sensor installed on the device that may possibly be used for pairing devices. We will be using a peripheral communication chip to control the wirless communication. This will free up processor time on the Tiva board allowing for more thorough sensor readings and calculations.

Research and Analysis

Battery Power Supply

There are multiple battery sizes and types available on the market. Many factors need to be taken into consideration to determine the correct battery for the correct application. In our case, a small multiple motor robot, a safe, cheap battery with a high energy density is needed. Lithium Ion Polymer batteries have a high energy density and small size, but they can be potentially dangerous. Lithium Ion batteries (common in laptops) can store lots of energy, but have relatively low current outputs, and are often quite expensive. Nickel Metal Hydride (NiMH) batteries are cheap, high energy density batteries that contain no toxic metals. This makes them a safer alternative to other options. There are many NiMH cells available for consumer use on the market, and lots of DIY projects recommend the use of NiMH battery packs. Given this information, our design will likely incorporate an NiMH battery pack as the onboard power supply [1].

Bluetooth Communication

Bluetooth® is a highly popular wireless communication standard. By implementing Bluetooth® in our system we greatly increase the portability and reliability of our robot. There are many advantages to using Bluetooth® over other protocols, such as IR technology. The two major advantages of Bluetooth® are that it does not require line of sight for communication and it can be readily modified to our needs using existing libraries and technologies.

We have decided to use the Emmoco EDB-BLE development board to control our wireless communications. This board will allow us to utilize the Bluetooth® 4.0 or Bluetooth® Low Energy (BLE) standard, which will be useful for exenting the battery life of our robot [2]. By having a separate development board for Bluetooth® communications we will be able to debug the wireless protocols seperately from the rest of the system. This will save us development time and costs.

One final benefit of Bluetooth® technology is multiple communication channels. By using the Bluetooth® stack we can stay connected to multiple control devices simultaneously. This means that we can have multiple remote controllers for the system. The EDB-BLE development board provides the em-framework which will allow our team to build custom control apps for moobile devices such as Android and iOS phones.

Wireless controller (Sony Dualshock 3®) and Interfacing

One of our goals is to fully interface with the Sony Dualshock 3® controller system. This will provide us with 2 10-bit joystick inputs, a 3-axis gyroscope, and 3-axis accelerometer for use as a controller. We will be able to provide very detailed instructions to our robot, so that the human to machine interfacing will feel natural and smooth. If possible, we will try to integrate the rotational orientation and translational acceleration readings from the controller to produce a hybrid-control model. This will allow to the user to not only direct the robot, but to "guide" the robot from a distance through natural motion.

Segway Physics

Voltage Regulators

Motors

Motor Control and PD Control

Gyroscopes

Risk Assessment and Contingency Plans

Safety should be one of the most important focuses of any project. For our project, we have identified potential hazards that could develop during the course of work. For any mechanical/fabrication work, there is always the possibility of shards/fragments/dust being expelled from the subject of work. In order to mitigate the potential eye damage, safety glasses are to be worn at all times when power tools are being used or there is ongoing testing involving moving parts.

Batteries introduce another hazard in the form of fire and explosion. It is quite common for batteries to overheat, and this can lead to dangerous explosions or burn related injuries. External forces can also damage batteries – this can lead to leakage of toxic chemicals. To mitigate these dangers, the team is planning to use a NiMH battery to negate the presence of dangerous chemicals. During motor load testing, the maximum current draw will be determined. From there, we will determine if we need a fan or some other heat sink to cool the battery during operation.

In the off chance that our battery fails or does not perform as expected, the team has planned to order a DC wall adapter to power the robot. While undesirable, a DC wall adapter provides a cheap way to ensure a power source in the case of an equipment malfunction.

The team has also identified several bottlenecks in our project development. These subsystems will all be worked on in parallel to minimize the down-time experienced. The systems identified include: the power supply/electronics, the mechanical design, and the sensing system. Without the mechanical frame and gyroscopes being developed, it will be impossible to calibrate any kind of motor control, and none of these systems will work without a power supply. The plan is to start by using the bench top amplifier and DC supplies to power the initial stages of the project, and switch to using our own electronics after the first milestone. This will allow time for the proper theoretical design and parts acquisition to take place.

Testing and Data Collection Plan

Testing Plan

Data Collection Plan

Cost Accounting

Project Schedule

Works Cited

[1] D. G. Calin, "Guide to choose suitable battery to build a robot." Internet: http://www.intorobotics.com/guide-to-choose-suitable-battery-to-build-a-robot/, June 2013.

[2] Nokia, "Wibree forum merges with bluetooth sig." Internet: http://www.wibree.com/press/Wibree_pressrelease_final_1206.pdf, June 2007.